Minuteman III ICBM
Launch Control Facility November-1
1.5 miles north of New Raymer
and State Highway 14
New Raymer Vicinity
Weld County
Colorado

HAER No. CO-84

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

Historic American Engineering Record
United States Department of the Interior
National Park Service
12795 West Alameda Parkway
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HISTORIC AMERICAN ENGINEERING RECORD

MINUTEMAN III ICBM LAUNCH CONTROL FACILITY NOVEMBER-1
Warren Air Force Base Missile Alert Facility

HAER No. CO-84

Location: Southeast Weld County, Colorado; 1.5 miles north of the town of New Raymer and State Highway 14.

USGS 7.5 Minute Quad: Raymer NE, Colorado, 1977

UTM Coordinates: 13.598440.4498330

Dates of Construction: 1962-1964, as part of Minuteman I system; 1975, converted to Minuteman III system

Architect/Engineer: Ralph M. Parsons Company, Los Angeles, California

Builder: Morrison-Knudsen Company, Boise, Idaho

Present Owner: United States Air Force, Warren Air Force Base, Wyoming

Present Use: Command post for the deployment of ten Minuteman III missiles

Significance: Launch Control Facility November-1 was one of 20 similar installations in "Wing V" of the country's Minuteman ICBM force. Land-based ICBMs played a vital role in American strategic policy during the Cold War. With the Navy's sea-based ballistic missile fleet and the Air Force's bomber fleet, they were part of the "Triad," the three major weapons systems that gave force to the concept of strategic deterrence. In the name of strategic deterrence, the U.S. Air Force spawned the most deadly weapons yet known and some of the most unique structures in the history of architecture.

Administered by Warren Air Force Base in Cheyenne, Wyoming, Wing V contained 200 of the nation's 1,000 operational Minuteman missiles. Field supervision of these nuclear weapons was vested in remote outposts such as Launch Control Facility November-1, each responsible for firing ten missiles upon higher command. By 1975, the original Minuteman missiles at Wing V were replaced by the Minuteman III. Longer and more powerful than its predecessors, the Minuteman III was equipped with an improved third-stage motor, which increased the range of the missile, a new post-boost propulsion system for better maneuvering, and an upgraded guidance system that enhanced computer memory and accuracy. But the missile's most significant improvement lay in its revolutionary warhead, a multiple independently targeted reentry vehicle (MIRV). This new warhead could deliver three hydrogen bombs to widely scattered targets, a capability that would "render current and contemplated antimissile defense systems largely inadequate," and would thus "thrust the world into a new era of weapons for mass destruction."

Historians: Christine A. Curran and Jeffrey A. Hess, 1997

Project Information: In 1995, Warren Air Force (WAFB) proposed to refurbish its 15 remaining Minuteman III ICBM Launch Control Facilities, which had been declared eligible for listing in the National Register of Historic Places. To mitigate its actions, WAFB provided funds to the National Park Service to prepare HAER Documentation of a representative facility. The study was completed under contract by Hess, Roise and Company of Minneapolis. Jeffrey A. Hess served as Principal Investigator, Christine A. Curran as Project Historian, and Clay Fraser as Project Photographer and Delineator.

DESCRIPTION

Missile Field Organization and Layout

In 1963, Strategic Air Command chose Warren Air Force Base as one of five strategic missile support bases in the country to deploy the Minuteman Intercontinental Ballistic Missile (ICBM) system. Warren was no stranger to the ballistic missile. In 1957, the Department of Defense had selected the installation to be the site of the nation's first ICBM base. The Atlas ICBM was deployed at the base from 1959 until its deactivation in 1965. The 90th Strategic Missile Wing arrived at Warren in 1965 to command and deploy the fifth Minuteman missile wing of the Strategic Air Command.

Through its personnel and facilities, Warren Air Force Base provides the Minuteman program with a variety of vital services, ranging from missile-crew training to missile maintenance to high-level command decisions. But the base itself shelters no operational missiles. Instead, the weapons are deployed in remote missile fields covering 12,600 square miles of Laramie, Goshen, and Platte counties of Wyoming; Banner, Cheyenne, and Kimball counties of Nebraska; and Weld and Logan counties of Colorado.

The nation's Minuteman force is organized as a series of administrative units called "wings." Each wing administers either three or four 50-missile "squadrons." Each squadron contains five "flights," with each flight housing one staffed command post ("launch control facility") and ten unmanned missile silos ("launch facilities"). Wing V at Warren hosts the 319th, 320th, 321st, and 400th Strategic Missile Squadrons. The 20 flights in these four squadrons are named in an alphabetical sequence that begins with Alpha, Bravo, Charlie and concludes with Romeo, Sierra, Tango. At Warren, Flights Alpha-Echo comprise the 319th Squadron, located in Nebraska and Wyoming; Flights Foxtrot-Juliet make up the 320th Squadron in Nebraska and Colorado; Flights Kilo-Oscar belong to the 321st Squadron, also in Nebraska and Colorado; and Flights Papa-Tango form the 400th Squadron, located entirely in Wyoming (see Figure 1).

Within each flight, the launch control facility is designated with the numeral "1," and the ten launch facilities with the numerals "2" through "11." A flight's numbering system corresponds roughly to its geographic layout. Site 1 occupies a central position, while the remaining sites form a perimeter. To minimize the damage inflicted by a single enemy warhead, the sites are separated from each other by several miles. In the perimeter arrangement at Warren, Site 2 is always on the north, with Sites 3 through 11 positioned, clockwise, in numerically ascending order. For brevity, Minuteman personnel often refer to missile-field facilities in simple alpha-numeric terms: A-1, N-7, K-11.

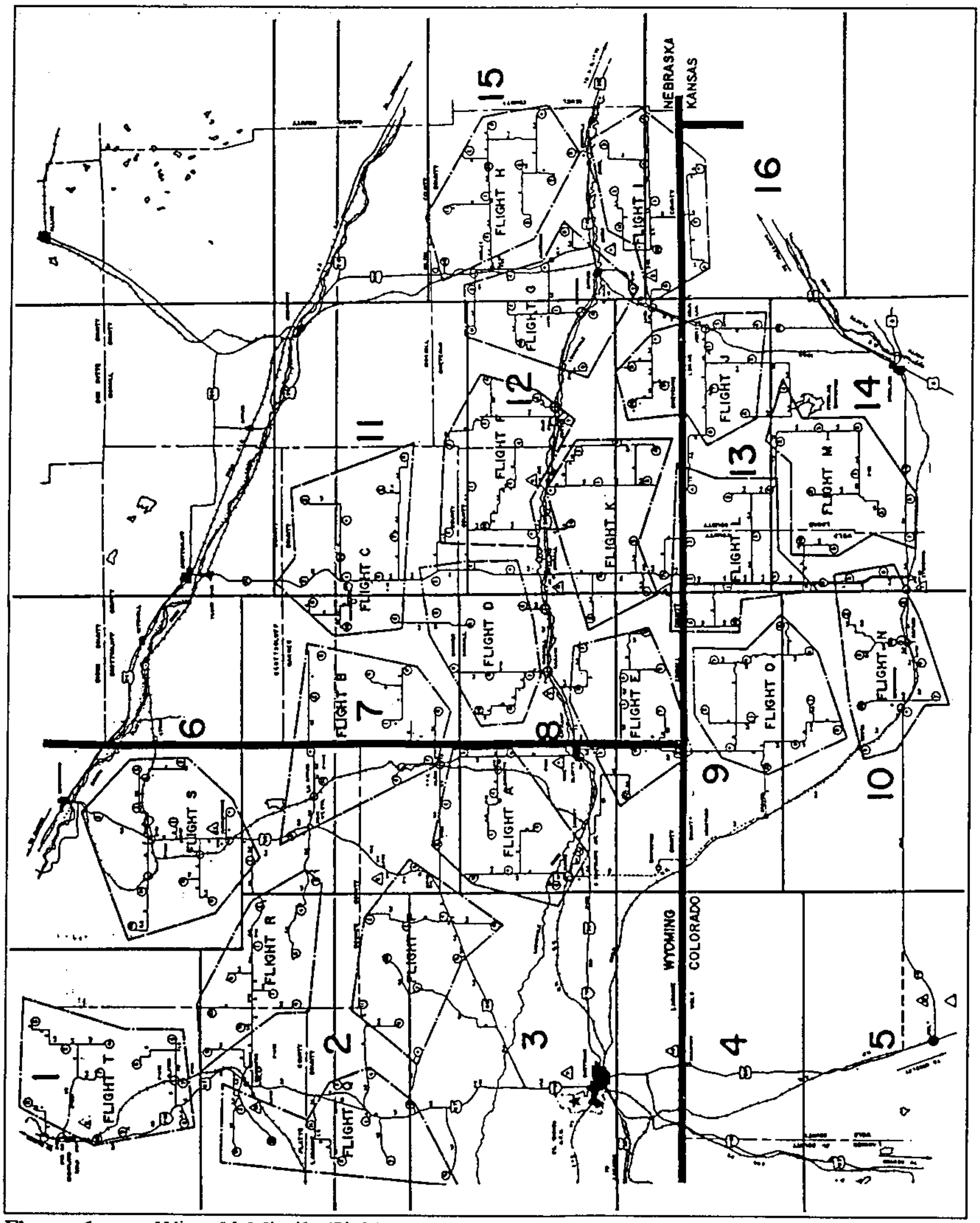

Figure 1 Wing V Missile Fields (Source: Historic Preservation Officer's Files, Warren Air Force Base, Cheyenne, Wyoming)

November Flight

Located in sparsely populated Weld County, Colorado, November Flight occupies the extreme southwest corner of the Minuteman "missile farm" administered by Warren Air Force Base. The November Flight missile field is roughly rectangular in shape, measuring approximately 23 miles east-west by 13 miles north-south. State Highway 44 cuts through the southern third of the missile field on an east-west course, while tracks of the Burlington Northern Railroad arc gently through the area, southeast to northwest. Visitors to November Flight look out at a high plains landscape of northeastern Colorado, a semi-arid region of rolling grasslands dotted by ranches and small trade centers.

Minuteman construction activities began at November Flight in October 1962, a month after the first ground was broken at the missile farm at Alpha Flight, approximately 50 miles to the northwest. Construction was completed in April 1964 and November Flight became fully operational in April 1965.[1]

In design, layout, and construction, the facilities at November Flight are representative of the other 19 Minuteman flights associated with Warren Air Force Base. The November missile field contains a centrally located Launch Control Facility (Site N-1) and ten perimeter Launch Facilities (Sites N-2 through N-11), which contain the actual missiles. Communication between the November Launch Control Facility and all other facilities in the 321st Squadron is facilitated by a 2,300-mile, buried, Hardened Intersite Cable System. This network gives Site N-1 the capability of launching not only the November Flight missiles, but all other missiles in the squadron as well, in the event that other launch control facilities were to be disabled by malfunction or enemy attack. Commercial telephone lines, land-line networks, and radio transmission systems provide Site N-1 with additional communication options, ensuring that command channels will remain open even if a specific system is lost.

November Launch Control Facility (Site N-1)

Situated about 70 air miles southeast of Warren Air Force Base, the Launch Control Facility for November Flight occupies a level 5.85-acre tract, set off from the surrounding grasslands by a barbed, chain-link perimeter fence. The site stands on the south rim of the South Pawnee Creek Valley, at an elevation of 4,790 feet. The closest town is New Raymer, Colorado, on State Highway 44, about 1.5 miles to the south. Overland access to the Launch Control Facility is by

[1] "History of the 90th Strategic Missile Wing, February 1964," Office of the Wing V Missile Historian, Warren Air Force Base, Cheyenne.

way of a graveled road, maintained by Weld County, that passes the west side of the site. A paved driveway, approximately 1,100 feet in length, leads eastward from the county road to an electrically operated sliding gate, which marks the entrance to Launch Control Facility N-1.

Site N-1 is the only manned facility in the November missile field. Its primary mission is to keep personnel and equipment in a state of readiness to launch the missiles of November Flight upon appropriate higher command. To fulfill its mission, Site N-1 constantly monitors the status of missile-field equipment and command communication from Warren Air Force Base. It also provides on-site personnel with support services, including food, lodging, and security.

The November Launch Control Facility is a compact complex of aboveground and belowground buildings and structures. Despite several modifications since the completion of original construction in 1964, the site still recalls its original appearance. Since these modifications occurred at all of the Minuteman missile fields associated with Warren Air Force Base, Site N-1 also resembles the other 19 launch control facilities at the installation. The primary features of the complex are listed below and are described in detail in subsequent paragraphs. The first three features in the list share integral construction, but for administrative and functional reasons they are traditionally treated as discrete entities.

Launch Control Support Building
Launch Control Center
Launch Control Equipment Building
Vehicle Storage Building
Hard Ultra-High-Frequency Antenna
Hard High-Frequency Receive Antenna
Soft High-Frequency Transmit-Receive Antenna
ICBM Super-High-Frequency Satellite Terminal Antenna
Survivable Low-Frequency Communications System Antenna
Helicopter Pad
Sewage Lagoon

Primary Features

<u>Launch Control Support Building</u>
The most prominent feature at the Launch Control Facility is the Launch Control Support Building. Structurally, the building is the aboveground extension of a blast-hardened, subterranean complex consisting of the Launch Control Center and the Launch Control Equipment Building (see descriptions in following sections). The Launch Control Support Building serves as a security center for the entire November Flight and provides accommodations for the eight-

person contingent assigned to the premises in three-day shifts. The staff consists of two flight security controllers, two two-person armed security teams, a cook, and a facility manager.

The Support Building is a one-story, side-gabled ranch-style building with a low-pitched roof and an asymmetrical footprint. The 33'-wide gable end faces the sliding entrance gate, almost immediately to the west. The 124'-long primary facade faces north, overlooking a circular parking area. The Support Building is built of light wood frame construction on a concrete-pad foundation. The roof is covered with asphalt shingles which terminate at tight, open eaves with metal gutters. A narrow vergeboard trims the gable ends. The building is sheathed with horizontal steel siding in a wide-lap weatherboard style. Complete with corner boards and stamped with a wood grain texture, this siding replaced the original asbestos-cementitious (Transite) shingles in the mid-1980s.[2]

A recessed entry on the north side (front) of the building shelters the primary entrance. A windbreak wall was added to further enclose the main door in the mid-1980s. All five door openings on the north side are original, as is the rest of the fenestration. Typical window openings hold one-over-one-light, double-hung, vinyl-clad wood sash glazed with insulating glass. These windows replaced the original one-over-one-light, double-hung wood sash in the early 1990s. The windows are grouped in pairs on the east end, and in a ribbon of six on the west end. On the gabled west end of the building, a partial-width, gabled bay extends 4'-6" beyond the main portion of the building. This end contains the security office, a function indicated by a bank of large windows prominently facing the sliding electric entry gate. On the main portion of the west end, a double overhead door was replaced by a pair of windows in the mid-1980s, when the interior space was converted from a garage to a bedroom. There are two original door openings still in use on this side of the building. On the south side (rear) of the building, the fenestration is grouped in pairs and ribbons of three. A 10'-wide lean-to breaks the south facade at the west end, sheltered under the gable of the main roof. The east end of the building has no door or window openings. A pad of concrete has been poured at this end in anticipation of a four-bedroom addition scheduled for completion in 1997.

The roof of the Support Building is pierced by ventilators, a boiler stack, a personnel hatch, and several exhaust fans. Floodlights are attached at the eaves at various intervals around the building.

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[2] Specific details about building renovations were obtained from a site visit by the authors on 26 August 1996; from a series of renovation plans dating from 1983 prepared for Strategic Air Command by F.E. Warren Air Force Base Civil Engineering Office; and from plans dating from 1992 prepared for Strategic Air Command by F.E. Warren Air Force Base. Copies of the plans were obtained from the Missile Engineering Office, F.E. Warren Air Force Base in Cheyenne. A chronology of the building's recent history was found in Correspondence File #O193TPT005 at the Wyoming State Historic Preservation Office in Cheyenne.

The Support Building is painted a cream color with dark brown trim on the doors and eaves.

The main entrance of the Support Building opens into a vestibule and short hallway, which provides entry into the security office to the west before terminating at the dining/recreation room. The dining/recreation room is large, with eight windows fronting south. The kitchen is located at the east end of the dining room. Also at the east end is an entrance to a corridor leading to five bedrooms, two latrines, and a utility room, which contains laundry facilities. Bedrooms and latrines in these spaces were modified in the mid-1980s to accommodate the addition of women crew members. Behind the north wall of the dining/recreation room are located the water treatment room and the telephone equipment room.

The water treatment room contains a pump installation and other water processing equipment. Each launch control facility requires approximately 2,000 gallons of water per day for drinking, cooking, bathing, boiler feed-water, and sanitary purposes. Reserve storage of at least 4,500 gallons is maintained at all times for emergency fire fighting. November-1 draws water from a well that is 1,188 feet deep. As at other Minuteman launch control facilities, the use of a deep well is intended to protect water quality from enemy actions.[3]

The telephone equipment room contains the telephone termination equipment for the Support Information Network, which is used primarily for the transmission of non-sensitive communications between various locations in the Minuteman wings. Installed and serviced by a commercial telephone company, the network commonly handles traffic dispatch for maintenance, security, housekeeping, and administrative personnel.

The west end of the dining/recreation room provides direct access to a sixth bedroom. Another modification of the mid-1980s, this room was originally a two-vehicle garage. Directly south, behind the bedroom wall, is an 8'x10' lean-to, used as a generator room. To the north of the bedroom is an elevator shaft and an adjoining corridor, which leads north to the security office. The elevator is the heart of the Support Building. It provides access for the two missile combat crew members pulling their 24-hour shift in the blast-proof Launch Control Center, approximately 50 feet below the surface.

<u>Launch Control Center</u>
The most important component of any Launch Control Facility is the underground capsule called the Launch Control Center. The Launch Control Center is a blast-proof, steel-reinforced concrete capsule within which is suspended a rectangular room called the "acoustical enclosure." The

[3] "Water Supply Treatment," Minuteman Service News 11 (December 1963): 3.

acoustical enclosure contains the equipment required for the monitoring and launching of the ten missiles in November Flight. It also contains life support equipment and minimal accommodations for two duty officers known as the commander and the deputy commander.

With a diameter of 29 feet, a length of 54 feet, and walls four feet thick, the concrete capsule provides the enclosure with a protective shell. The acoustical enclosure measures approximately 12 feet wide and 31 feet long. It sits on a steel-framed platform, officially known as an electrical-mechanical equipment base. To reduce shocks from earthquakes or nuclear attacks, the enclosure is mounted in a shock-absorbing system. One set of shock absorbers (isolators) carries the weight of the acoustical enclosure. These four isolators, located near each corner of the enclosure, hang from heavy chains attached to the ceiling of the capsule. The shock isolators limit the vertical movement of the enclosure platform. A second set of shock absorbing devices, called sway dampers, controls the horizontal movement of the platform and are located beneath the acoustical enclosure.

The walls and ceiling of the acoustical enclosure are made of hollow, perforated steel panels filled with sound-absorbing material. The floor is made of removable steel plates covered with sheet vinyl and carpet. Compartments beneath the floor contain survival equipment, emergency batteries, and a motor generator. Four recessed florescent lighting panels centered in the ceiling illuminate the interior of the enclosure. A beige fabric liner, attached to the ceiling framework on either side of the light panels, was added in 1988 to cover wiring and cables and to help reduce noise inside the enclosure. Lining the west wall of the enclosure are heavy aluminum electronic racks containing computer equipment, radio transmitters and receivers, a telephone relay system, and a power control panel. Equipment racks, panels, and shelving are painted in various shades of gray, pale green, and cream. The enclosure is air-conditioned to remove heat from the electronic equipment racks, as well as to maintain a comfortable climate for the crew on duty. In addition to air-conditioning, the enclosure is equipped with an emergency life support system. Outdoor air can be brought in through a chemical-bacteriological-radiological filter, or, if automatic blast valves shut off the outside air supply, oxygen can be regenerated using a hand-pumped unit stored within the capsule. A chilled brine tank located at one end of the enclosure is used for emergency air conditioning. Primary and standby electrical power are provided either commercially or by a standby generator. Emergency power is supplied by a storage battery set. The acoustical enclosure is also equipped with a stainless steel latrine, a small refrigerator/microwave oven unit, and a curtained sleeping compartment located at the north end.

Located along the east side of the enclosure are two desk-like consoles. Positioned in front of each console is a swiveling, high-backed operator's chair, fitted with a seat belt and shoulder harness. Both chairs are anchored on a pair of rails running several feet along the length of the enclosure. This arrangement provides the console operators with easy access to the myriad of components located at the consoles. The original consoles, equipped with 1960s-era computer technology, were replaced in 1993-1994 with updated consoles and hardware.[4] The two consoles serve different functions. The launch control console allows the commander to continually monitor the operational and security status of each of the ten missiles in November Flight. Next to the launch control console is the deputy commander's communications control console. It contains the radio and telephone equipment that enables the crew to communicate with other launch control facilities, base headquarters, and the Strategic Air Command. At the side of each console is a small panel containing a spring-loaded, key-operated launch switch. The keys to these switches are kept in a double-padlocked, steel box mounted above the deputy commander's console. The two consoles are space sufficiently apart to prohibit a single crew member from activating the missiles on his or her own.

Access to and from the Launch Control Center is provided by an opening at the south end of the capsule. The opening is protected by an eight-ton blast door. Designed primarily to withstand the effects of nuclear blast and to provide an environmental seal, The blast door is constructed of welded steel shells filled with concrete grout.

Launch Control Equipment Building
Equipment located in the underground Launch Control Equipment Building provides environmental control and power required to make the Launch Control Center self-sufficient during the prolonged periods of isolation that could occur after a nuclear attack. The Equipment Building is a blast-hardened structure of steel and reinforced concrete, but it is not a cylinder with rounded ends like the Launch Control Center. It is a flat-bottomed structure with sloping sides, a rounded top, and flat ends. The equipment it contains is supported by a floor suspended on 12 coil-spring shock isolators. There are no sway dampers as in the Launch Control Center. Since the Equipment Building is manned only during relatively short periods of equipment maintenance, it is not fitted with a blast door.

The Equipment Building at November-1 is aligned with the Launch Control Center on a common axis. Together, they are located perpendicular to the aboveground Support Building, underneath its west end. This alignment differs from Minuteman Wings I and II, where only the launch control centers are located underground, and the launch control equipment buildings are aboveground, operating out of the support building. The difference in these two designs was the result of a strategic policy change instituted during the early days of the Kennedy administration. Air Force historian Clyde Littlefield explains:

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[4] More details are provided on the console update program at the end of this report, under section heading, "The End of the Cold War."

> During the first half of 1961, the national strategic concept completed a shift from massive retaliation to controlled response. In consonance with the earlier concept, the Air Force had designed the Minuteman as a quick reacting mass attack weapon. . . . A combat crew would fire a minimum of ten missiles. In order to conform to the new concept, engineering changes had to be made to allow a combat crew in a control center to switch targets and to fire one or more missiles selectively, conserving the remainder for later use. . . . Greater flexibility in targeting and firing required a significant extension to the limited survival time [of each operational site]. The [original] Minuteman facility design did not provide for the protection of the power supply. . . . At a control center, power generators were above the ground. . . . When and if these generators stopped functioning, the operational potential of the system would be reduced to only six hours. Revised strategic concepts required that the weapon survive at least nine weeks after an initial enemy attack.[5]

In September 1961, Air Force headquarters authorized the Ballistic Systems Division to proceed with plans to harden the generators against nuclear blast. The Division decided to install the generators in hardened underground capsules, located next to the Launch Control Center. Construction was well underway at Wing II, located at Ellsworth Air Force Base, by the time these changes were proposed. Consequently, the underground equipment capsules were introduced with the third Minuteman wing at Minot Air Force Base, North Dakota, in 1962.

The main components located in the Equipment Building are an air conditioning unit, an environmental control system, power distribution equipment, and a standby diesel generator. Blast valves, installed in the air ducts running between the Equipment Building and the Launch Control Center and between the Equipment Building and the air intake and air exhaust shafts, protect the air supply from contamination. In the event of an emergency, the blast valves are designed to automatically seal off the capsules from the surface air. Buried on the east side of the Equipment Building is a 3,700-gallon water tank, and buried on the west side are a 14,000-gallon diesel fuel storage tank and an emergency sewage tank. The building's apparatus would theoretically allow the equipment and crew in the Launch Control Center to function for up to nine weeks in isolation.

Between the Equipment Building and the Launch Control Center is a reinforced concrete room called the tunnel junction, which provides access to both facilities. The tunnel junction leads through a second blast door to a 50-foot access shaft containing an elevator and a vertical ladder

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[5]Littlefield, The Site Program, 80-81.

to the aboveground Support Building. It is possible that a nuclear attack could destroy the access shaft and tunnel junction, the normal exit for the missile combat crew. For this reason, there is an emergency escape tube at the north end of the Launch Control Center. The tube is made of corrugated steel and measures three feet in diameter. Extending from the ceiling of the Launch Control Center, it penetrates upward through the earth for 52 feet, terminating just below surface. The tube is filled with sand to prevent it from collapsing. In the event of an emergency, the crew would dig out the sand, crawl up the tube, and escape through a hatch at ground level.

Vehicle Storage Building

A one-story, front-gabled Vehicle Storage Building stands at the entrance to the November-1 Launch Control Facility, a short distance inside the electric gate. The style of the building matches the simple, utilitarian style of the Launch Control Support Building, just to the south. The Vehicle Storage Building was constructed in 1966, as the last major feature of November-1's configuration. Measuring 40' x 32,' the building was constructed of light wood framing on a reinforced concrete pad foundation. The building's primary facade faces southwesterly and includes a large central doorway flanked by two smaller openings of the same type. The doorways are fitted with overhead steel doors patterned with a horizontal grid. The original cementitious-asbestos shingle siding (Transite) was replaced in the mid-1980s by horizontal steel siding in a wide-lap weatherboard style. Trimmed with metal cornerboards and stamped with a wood-grain texture, the siding is painted a cream color, with dark brown trim on doors and eaves. The roof is covered with light brown asphalt shingles which terminate at tight, open eaves and a narrow vergeboard trim at the gable ends. The southeast-facing side of the roof is pierced at the northeast corner by a furnace flue. On the northwest-facing side is a gravity vent. Floodlights are attached at the eave corners at the primary (southwest) facade of the building. Two doors are located on the southeast side of the building. One accesses a small interior furnace room in the northeast corner, and the other provides access to the rest of the interior storage space. Pavement meets the garage doors at the primary facade, then curves around the southeast side of the building to form a small patio, which extends the length of the southeast facade. The remainder of the site surrounding the storage building is covered with gravel and grass.

Age and deterioration forced the demolition of the storage building's original oil furnace and diesel fuel tank in 1995. Although the replacement furnace remained inside, a new 1,000-gallon fuel tank was placed outdoors, directly to the rear (northeast) of the building, on a reinforced concrete pad surrounded by a vertical picket fence. A pole topped with a weathervane extends from inside this enclosure. Originally attached at the east end of the Launch Control Support Building, the weathervane was relocated to the Vehicle Storage Building in the mid-1980s, when the Support Building received new siding.

Associated Structures

Several aboveground and underground radio antenna structures are dispersed within the Launch Control Facility's fenced grounds. These antennae are part of a complex communication network developed to maintain missile launch control and communication during and after a nuclear attack.

Hard Ultra-High-Frequency Antenna

Approximately 125 feet east of the Vehicle Storage Building is the blast-hardened Ultra-High-Frequency Antenna. The primary purpose of the installation is to provide a channel between the N-1 Launch Control Center and the Airborne Launch Control Center, an aircraft that functions as a back-up control center in the event ground-based control centers are incapacitated by a nuclear blast. The antenna was also designed to receive alert, launch, and execution orders from Strategic Air Command communications rockets and to permit communications via Air Force satellites. The Ultra-High-Frequency Antenna consists of a massive, cast-steel frustum, bolted to a thick, reinforced-concrete square slab. Surmounting the frustum is a conical, white fiberglass weather dome.

Hard High-Frequency Receive Antenna

High-frequency radio provides Strategic Air Command with point-to-point voice communications as a backup of the land-line systems for control of the weapon systems. The High-Frequency Receive Antenna is set into the ground approximately 67 feet south of the Launch Control Support Building. The structure consists of a reinforced-concrete cylinder measuring approximately 16 feet in diameter and 37 feet deep (outside dimensions). The cylinder is covered by a concrete cap. Distributed evenly around the perimeter of the structure are five small ports, each containing a slender, ballistically actuated, steel, monopole antenna. This antenna system was deactivated in 1971. When it was still in use, one monopole extended from the cylinder at all times. If the exposed antenna were to have been damaged during an attack, a replacement could have been quickly deployed through the detonation of an explosive squib in an adjacent port.

Survivable Low Frequency Communications System

This is a low-frequency radio teletype which has receive-only capability. Installed in 1966-1967, the system consists of a buried antenna, a receiver installed in an electronic rack inside the Launch Control Center, and a miniature teleprinter mounted on the crew console in the Launch Control Center.

ICBM Super-High Frequency Satellite Terminal

This antenna structure is located a few feet from the southwest corner of the Launch Control Support Building. It consists of an aboveground pole with a large white rounded dome.

Weather Antenna
This antenna is mounted on a wooden pole against the north side of the Launch Control Support Building.

Water Tanks
Well water is stored against the north side of the Launch Control Support Building in underground tanks. Access covers appear directly outside the doors to the water treatment room in the Support Building.

De-watering Well
Located several feet from the south side of the Launch Control Support Building, this pump prevents groundwater from building up and damaging the Equipment Building, Launch Control Center, and associated underground facilities. November-1 Launch Control Facility was one of several Launch Control Facilities in Wing V with troublesome high ground water.

Intake/Exhaust Ducts
Approximately 50 feet from the southwest corner of the Launch Control Support Building stand two large brown ducts which provide intake and exhaust air to the underground Launch Control Center and Equipment Building. The ducts are fitted with 36-inch blast valves designed to seal off the subterranean facilities from outside air in the event of a nuclear attack.

Helipad
Although helipads were not installed at Wing V launch control facilities until 1969, helicopters have served the wing since 1965. Fifteen helicopters were originally assigned to Warren, cutting down road time for base vehicles, which were averaging 600,000 miles per month transporting people and food supplies between the base and the Minuteman launch control facilities.[6] The concrete helipad at November Flight measures 50' x 50'. Located outside the security fence at the north end of the Launch Control Facility, it receives any one of six UH-1N "Twin Huey" helicopters currently maintained by Warren Air Force Base.

Sewage Lagoon
Located just outside the perimeter fence, approximately 200 feet northwest of the Launch Control Support Building, is a sewage lagoon used for treating waste materials produced at the Launch Control Facility. The sewage lagoon is an open settling basin with a 39,500-cubic-foot capacity. Surrounded by an earthen berm, it is 118 feet square at ground level and tapers to 70 feet square

[6] 90th Strategic Missile Wing: 1 October - 31 December 1965, 7. This is a quarterly history obtained in the office of the Wing V missile historian, Warren Air Force Base, Cheyenne.

at the base.

HISTORICAL SIGNIFICANCE[1]

On 7 January 1954, President Dwight D. Eisenhower delivered his first State of the Union Address to a joint session of Congress. He began his speech with a lengthy discussion of foreign affairs and defense policy. After stating his belief that "American freedom is threatened while the Communist conspiracy exists in its present scope, power and hostility," he outlined his plans for defending the nation against that threat: "We will not be aggressors," he said, "but we . . . have and will maintain a massive capability to strike back."[2] Eisenhower's comments -- which were translated into the catchphrase "massive retaliation" -- reflected the doctrinal basis behind much of the nation's strategic planning during the Cold War era.

The threat of "massive retaliation" kept the United States and the Soviet Union locked in a nuclear arms race for almost 30 years. Americans spent the bulk of that period pouring billions of dollars into the development of a nuclear arsenal they hoped would deter a first strike by the Soviet Union. The long-standing defense policy of "deterrence" was described by General Thomas D. White, Chief of Staff, U.S. Air Force, in 1957:

> As long as the Soviets recognize that by striking the U.S. they themselves will be destroyed, it is not likely that they will consider war profitable. Since the prime purpose of our military forces is to prevent war, they will be most effective if we never have to use them.[3]

To deter an attack meant being able to strike back in spite of it. It meant a capability to strike

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[1] This narrative draws heavily on the "statement of significance" section of John Lauber and Jeffrey A. Hess, "National Historic Landmark Nomination for Minuteman II ICBM Control Facility D-1 and Launch Control Facility D-9, Ellsworth Air Force Base," prepared by Hess Roise and Company, Minneapolis, Minnesota, for Rocky Mountain Regional Office, National Park Service, Denver, Colorado, 1997.

[2] "The Text of President Eisenhower's Message to Congress on the State of the Union," New York Times, 8 January 1954. Subsequent references to the New York Times will be identified by the abbreviation NYT.

[3] Thomas D. White, "The Ballistic Missile -- An Instrument of National Policy," USAF Air University Quarterly Review 9 (Summer 1957): 2.

second.[4] For the United States it also meant developing a basing system for nuclear weapons that was almost inconceivable in cost, scale and technological requirements. In the name of "strategic deterrence" the U.S. Air Force spawned the most deadly weapons yet known and some of the most unique structures in the history of architecture.

The Origins of the Arms Race

Following the Second World War, the Soviets failed to demobilize as the Western allies had done. The Soviet Union had suffered massive losses in the war against Nazi Germany and considered Eastern Europe a "buffer zone" against possible invasion from the West. As Soviet military forces installed Communist governments in several Eastern and Central European countries, Americans, in contrast, were disarming at a rapid pace. The monopoly on the atom bomb had given the United States an edge in the immediate postwar era. Exploiting its position as the sole possessor of the bomb, Americans placed little priority on maintaining a conventional military force. Congressional support for military readiness during the immediate postwar years was almost nonexistent. By early 1947, America's armed forces had been cut from their wartime strength of 12 million to 1.5 million. On Washington's Capitol Hill, the primary issue was what could be done to speed demobilization -- to "bring the boys home."[5]

However, the United States was soon compelled to take action against what it saw as an emerging threat to democracy in Western Europe. George Kennan, a diplomat at the U.S. Embassy in Moscow, warned that Soviet foreign policy was rooted in a fanatical "expansionism" that was ultimately bent on disrupting American society, destroying the American way of life, and breaking the international authority of the American state. The only way to deal with this threat, Kennan suggested, was for the United States to adopt a policy of "patient, but firm and vigilant containment of Russian expansive tendencies."[6]

In hopes of putting the "containment" policy into practice, the United States, Canada, and ten Western European countries entered into the North Atlantic Treaty Organization (NATO) in April 1949, with the aim of establishing a military counterweight to Soviet forces in Europe. According

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[4] Albert Wohlstetter, "The Delicate Balance of Terror," Foreign Affairs 37 (January 1959): 213.

[5] David Halberstam, The Fifties (New York: Villard Books, 1993), 27.

[6] Kennan discussed Soviet expansionism in a 1946 telegram to the State Department. See George Kennan, "The Kennan 'Long Telegram,'" in Kenneth M. Jensen's Origins of the Cold War (Washington: United States Institute of Peace, 1991), 28.

to its charter, NATO had a defensive purpose: "The parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all." Because the United States had the atom bomb, it assumed a leadership role in confronting Soviet policy, both in and out of NATO. The resulting military standoff between "East" and "West," with all of its attendant economic and political tensions, became known as the Cold War.

America's monopoly on the atomic bomb ended in September 1949, when the Soviet Union exploded a nuclear device of its own. This event shocked American scientists and intelligence analysts, who had drastically underestimated Russian nuclear technology. The American military responded with an even more powerful weapon -- a thermonuclear bomb that used a small atomic trigger to initiate a fusion reaction in hydrogen isotopes. When the United States successfully tested its first hydrogen bomb in 1952, the weapon promised to reestablish the nation's nuclear superiority once and for all. But at the end of August 1953, the Soviets also detonated a sophisticated hydrogen bomb. Many American military experts believed that the new Russian weapon was capable of being delivered by an intercontinental ballistic missile (ICBM). For the first time, the Soviet Union seemed poised to take the lead in the arms race.

The Origins of the American ICBM Program

American military planners had initiated several attempts to develop ballistic missiles immediately after World War II. For the most part, these studies were based on Germany's V-2 rocket which had been used with moderate success against the Allies at the very end of the war. But during the late 1940s, American nuclear superiority had seemed secure, and the missile programs were allowed to languish.

America's involvement in the Korean War in 1950 forced the military to reevaluate its weapon systems. Early in 1951, the Air Force Air Research and Development Command set up Project MX-1593 to pursue earlier missile studies performed by Convair Corporation under a 1946 contract with the Army Air Corps (precursor to the Air Force). In 1947, funding for that contract was cut and the project dropped, but Convair continued research on its own, steadily advancing the state of missile technology. In 1951, with the coming of the Korean Crisis, the Air Force once again turned to Convair. Project MX-1593 was code-named "Atlas." It was a low-priority project, but it marked the renewal of government-sponsored research into ballistic missiles by the United States.

The advent of the Soviet hydrogen bomb in 1953 ended the complacency that had tethered the U.S. ballistic missile program since its beginning. The Air Force asked two independent organizations to evaluate the strategic importance of the intercontinental ballistic missile. One study was by Dr. Bruno Augenstein, a RAND Corporation physicist who believed that "if the

Soviet Union beat the United States in a race for the ICBM, the consequences would be catastrophic."[7] Concurrently, the Air Force assembled the Strategic Missiles Evaluation Committee, a group of scientists headed by Dr. John von Neumann, an eminent Princeton University mathematics professor. Von Neumann's group, code-named the "Teapot Committee," was explicitly ordered to investigate "the impact of the thermonuclear [bomb] on the development of strategic missiles and the possibility that the Soviet Union might be somewhat ahead of the United States."[8]

Both groups presented their findings shortly after Eisenhower's 1954 State of the Union Address. Both studies reached essentially the same conclusions: recent advances in thermonuclear technology made an ICBM practical, and the Soviet Union was intent on achieving it. Furthermore, the American scientists agreed, such a device "could be developed and deployed early enough to counter the pending Soviet threat <u>if</u> exceptional talents, adequate funds and new management techniques suited to the urgency of the situation were authorized."[9]

The Air Force quickly made the Atlas ICBM its top priority. By mid-May 1954, officials had mapped out a development plan for the new weapon, and at the end of June, Air Force Vice Chief of Staff General Thomas D. White ordered the Air Research and Development Command "to proceed with the development of an ICBM at the highest speed possible, limited only by the advancement of technology in the various fields concerned."[10] In July the Air Force established a special project office to administer the program. The new agency was to be based on the West Coast, and was called the Western Development Division. The organization's mission was considered so important to national security that "even its initials, WDD, were classified beyond top secret."[11]

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[7] Fred Kaplan, <u>Wizards of Armageddon</u> (Stanford, CA: Stanford University Press, 1991), 112-113.

[8] Dennis J. Stanley and John J. Weaver, "An Air Force Command for R & D, 1949-1976. The History of ARDC/AFSC," Office of History, Headquarters, Air Force Systems Command, N.C., n.d., 22, in USAF Historical Research Agency, Maxwell AFB, Montgomery AL, Document K234.04-39. Hereafter, materials from this collection will be cited as HRA, with appropriate locators.

[9] Robert L. Perry, "The Atlas, Thor, Titan, and Minuteman," <u>The History of Rocket Technology</u> (Detroit: Wayne State University Press, 1964), 144.

[10] Air Force Ballistic Missile Test Program," 1957, 1, in the archives of the Ballistic Missile Organization History Office, Norton AFB, San Bernardino, CA, in Box L-1. Henceforth, materials from this collection will be cited as BMO, with appropriate locators.

[11]Kaplan, <u>Wizards</u>, 116.

A newly promoted, 43-year-old brigadier general named Bernard A. Schriever was selected to head the new agency. By 1960, the young officer was expected to place a fully operational ICBM weapon system into the hands of the Strategic Air Command, the military command responsible for the Air Force's strategic nuclear weapons. On 5 August 1954, Schriever and a small group of military officers converged on an abandoned parochial school in the Los Angeles suburb of Inglewood. To avoid arousing the curiosity of nearby residents, the officers had been instructed to leave their uniforms home and to arrive at their new headquarters in civilian clothes. In this inconspicuous but carefully secured setting, the handpicked staff of the Western Development Division began organizing the effort to build an effective ICBM.

The First Generation: Atlas and Titan

In concept, the Atlas was essentially a highly evolved version of the German V-2 missile. Like the V-2, the Atlas was powered by rocket engines that burned a mixture of liquid fuel and oxidizer. But while the V-2 had an effective range of only a few hundred miles, the Atlas was expected to deliver its payload to a target more than 5,000 miles away. Convair Corporation could have attempted to meet this requirement by building the Atlas as an enormous version of the V-2. Instead, the company's engineers sought a more sophisticated solution. Realizing that they could greatly extend a missile's range by reducing its weight, they decided to equip the Atlas with an innovative, ultra-light airframe. The missile was assembled from rings of paper-thin stainless steel, stacked together like stovepipes and welded at the seams to form a seemingly flimsy cylinder. This cylinder was then inflated with nitrogen gas to give the missile its structural integrity.

By 1954, the Atlas was the nation's most advanced ballistic missile. Nonetheless, the missile was still years away from production. No prototype had ever been flight tested, and some skeptics feared that when the Atlas's powerful engines were fired for the first time, its thin-skinned airframe would simply buckle in on itself, leaving America's hopes for an ICBM lying on the launch pad like a gigantic ball of tin foil.

General Schriever and his staff were well aware of these concerns. So while they rushed ahead with the Atlas program, they also began looking for a backup system. During the fall of 1954, the Western Development Division asked several aircraft manufacturers to investigate the feasibility of building an alternate ICBM. The studies were completed by Christmas, and in January 1955, General Schriever presented their findings to his superiors. By the end of April the Air Force had authorized the Western Development Division to proceed with the development of a backup missile. In October 1955, the Glenn L. Martin Company received a government contract to produce a new ICBM called the Titan. Like the Atlas, the new Titan would use liquid propellants, but its advanced two-stage design would allow the missile to utilize a conventional

-- and more reliable -- airframe.

In 1955, the Office of Defense Management issued a report strongly urging the development of an intermediate range ballistic missile (IRBM). Intelligence reports indicated that the Soviet Union had made significant advances in the IRBM field, a situation that posed a serious threat to America's Western European allies. The IRBM's less restrictive performance requirements meant that the missile could be developed and placed in operation more quickly than the larger, more complex ICBMs. By the end of 1955, President Eisenhower had assigned the highest national priority to the IRBM development programs, placing them on an equal footing with the ICBM programs. By that time, contracts had been awarded to Douglas Aircraft Company to develop the Thor missile for the Air Force, and to Chrysler Corporation to produce the Jupiter missile for the Army. Both these missiles were designed as single-stage, liquid-fuel rockets equipped with all inertial guidance. They were to have a range capability between 1,500 and 3,000 nautical miles. The Thor was stored horizontally, and the Jupiter vertically, on tactical, field-deployed launchers.[12]

By 1956, the Air Force had made the decision to deploy the Thor IRBM from a European site. The United States was under pressure from the NATO alliance to respond more visibly to Russian advances in missile development. American IRBMs stationed in Europe represented a visible presence of Western missile strength on the European continent, and they clearly demonstrated a commitment against communist aggression in Western Europe.[13] By 1960, the United States had deployed 60 Thor missiles in Great Britain, 30 Jupiter missiles in Italy, and 15 Jupiter missiles in Turkey.

Even for the fast-paced world of missile technology, the IRBM systems were ephemeral creations, phased out by the Kennedy administration in 1962, when it became clear that the United States was on the verge of emplacing its first ICBMs. Despite the fact that the Thor and Jupiter missiles were operational for only a short time, Strategic Air Command's deployment and maintenance of these liquid-fuel, medium-range weapons gave the American military invaluable practical experience to draw upon when it came time to activate the more complex ICBMs. However, well before Strategic Air Command was able to deploy any intercontinental missiles at all, the Soviet Union struck its most disconcerting blow.

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[12] From Snark to Peacekeeper: A Pictorial History of Strategic Air Command Missiles (Offutt AFB, NE: Office of the Historian, HQ Strategic Air Command, 1990), 51.

[13] Ibid, 57.

The Missile Gap

On 4 October 1957, the Soviet Union announced that it had used a liquid-fuel ICBM to launch a 185-pound artificial satellite called "Sputnik" into orbit around the Earth. This demonstration of Russian technological prowess caused many American scientists and politicians to fear that the Soviet Union had opened a significant "Missile Gap" that would give them a commanding lead in the arms race. "If the Reds can put a 185-pound object into space," they reasoned, "they also have the ability to fire long-range missiles."[14] Within a few months, American journalists and intelligence analysts began to assert that the Soviet missile force could outnumber the American arsenal by as much as 16 to one by 1960.[15] America's growing sense of insecurity was not lost on Soviet officials, who gleefully boasted that their factories were turning out missiles "like sausages."[16]

Facing severe criticism for allowing the United States to fall behind the Soviet Union in the arms race, the Eisenhower administration responded that its missile programs had never been intended to merely "put something together" in a hurry. The programs were carefully designed, said a spokesperson, first to "attain perfection," and then to "develop the ability to produce in volume once that perfection is achieved."[17]

But America's first-generation ICBMs were neither perfect nor mass producible. In fact, observed the Wall Street Journal a few weeks after Sputnik, "their weaknesses are so profound that . . . generals are sure [the missiles] will be discarded altogether after the first half-dozen years."[18] The Atlas and Titan missiles were extraordinarily complex, hand-crafted machines, containing as many as 300,000 components, each of which had to be maintained in perfect operating condition in order for the missile to successfully complete its mission. The liquid propellants that powered their engines were volatile and corrosive, and could not be placed into the missiles' tanks until immediately before launch. The fueling process could take as long as two hours. Consequently, instead of being "stable weapons in a state of permanent readiness," these early ICBMs would

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[14] "Russia's Moon," Wall Street Journal, 7 October 1957. Subsequent references to this publication will be identified by the abbreviation WSJ.

[15] Roy Licklider, "The Missile Gap Controversy," Political Science Quarterly 85 (December 1979): 605.

[16] John Prados, The Soviet Estimate (New York: Dial Press, 1982), 77.

[17] Ibid.

[18] "Myths and Missiles," WSJ, 21 November 1957.

"require the desperate and constant attention accorded a man receiving artificial respiration. A missile unit will be no push-button affair but will require a highly trained crew . . . several times as large as the largest bombing crew." Many of these problems could be solved, the Journal suggested, by developing a greatly simplified "second generation" of missiles powered by solid-fuel rocket engines.[19]

Weapon System "Q"

"A lot of work had been done on solids prior to the initiation of the ICBM program in 1954," recalled Schriever in a 1973 interview, "but there were a number of things that ruled against using solids at that time."[20] The solid propellants available in the mid-1950s could not provide the power needed to hurl a heavy warhead across an ocean. Solids were difficult to manufacture. They were often hard to ignite, and once ignited, there was no way to control their combustion or direct their thrust. Given these constraints, liquid-fuel missiles, despite their "volatile, hard to handle" propellant mixtures, presented "the only immediate way to go ahead" in 1954.[21]

However, the Air Force did not entirely abandon its efforts to develop a viable solid-propellant missile. In 1956, General Schriever had reluctantly approved a low-level research program "aimed toward the evolution of a high-thrust . . . solid-fuel rocket."[22] The person he selected to head the program was Colonel Edward Hall, Chief of Propulsion Development for the Western Development Division. According to Air Force historian Robert Perry, Hall was a "near fanatic" about the potential of solid-fuel missiles.[23]

Despite the Air Force's half-hearted support for the solid-fuel development program, Hall and others diligently pursued their research, and within two years, most of the technical problems involved with solid-fuel rocket engines had been solved. In August 1957, the Air Force asked Hall to help develop a medium-range, solid-fuel missile that would serve as a land-based counterpart to the Navy's submarine-launched, solid-fuel Polaris which was currently under

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[19] Ibid.

[20] General Bernard A. Schriever, interviewed by Major Lyn R. Officer and Dr. James C. Hasdorff, Washington, D.C., 20 June 1973, 6-7. HRA K239.0512-676.

[21] Roy Neal, Ace in the Hole (Garden City, NY: Doubleday and Company, Inc., 1962), 27.

[22] Perry, "The Atlas, Thor, Titan, and Minuteman," 155, 157.

[23] Ibid, 155.

development.[24] Within two weeks Hall had drawn up specifications for a remarkable new missile whose range could be varied by simply assembling its three interchangeable propulsion stages in different combinations.

The new missile, dubbed "Weapon System Q," was "the first strategic weapon capable of true mass production," writes Duke University historian George Reed. "To Hall, the new missile was the perfect weapon for a defense policy characterized by minimum expenditure and massive retaliation; and he urged that this be its chief selling point."[25] Sputnik made it considerably easier for him to make the sale. A few days after the Soviets launched their satellite, Hall went to the Pentagon with General Schriever to begin building support for the new missile. As they ascended through the ranks of the military hierarchy, Hall continued to refine his plans. By the end of the year, he had determined that "the ICBM version of Weapon System Q would be a three-stage, solid-fuel missile approximately 65 feet long, weighing approximately 65,000 pounds, and developing approximately 100,000-120,000 pounds of thrust at launch."[26] The missile would be stored in dispersed underground silos, hardened to resist the forces of a nuclear blast, and "would accelerate so quickly that it could fly through its exhaust flames and not be significantly damaged."[27] The weapon system was designed to make maximum use of production line capability and require a minimum of trained men to launch it.[28] The ratio of men required per weapon was lower than any other strategic system in existence with an early estimate of seven to nine men per missile.[29]

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[24] The effort to develop a viable solid-fuel ICBM spawned a spirited rivalry between the Air Force and the Navy during the late 1950s. In 1958 Colonel Hall gleefully recalled an episode that had taken place the previous summer: "The original Polaris program fell flat on its face and the Navy requested from BMD the work statements covering its engine development work . . . with the hope of exploiting these to continue to prosecute what otherwise would . . . have become a moribund program. The Air Force complied happily and the Navy reoriented its work to proceed along the lines laid down by the Air Force. . . . It is seen then that the basic work required to establish feasibility for Polaris stems directly from Air Force activity." Hall, "Epitaph," 7.

[25] George Reed, "U.S. Defense Policy, U.S. Air Force Doctrine and Strategic Nuclear Weapon Systems, 1958-1964: The Case of the Minuteman ICBM," Ph.D. diss., Duke University, 1986, 58-59.

[26] Ibid, 58.

[27] Ibid.

[28] Neal, Ace in the Hole, 16.

[29] Ibid, 130.

At the beginning of February 1958, Hall and Schriever presented the System Q concept to the Secretary of the Air Force and the Secretary of Defense. "We got approval of [the] program within 48 hours," Schriever remembered many years later.[30] The officers immediately gave the project a new name. On 28 February 1958, the New York Times reported that the Air Force had been authorized "to produce an advanced type of ballistic missile . . . called Minute Man."[31]

Building an Industry

It is hard to imagine just what a monumental task this authorization placed in the hands of the Air Force. In order to produce the Minuteman, the Air Force would have to produce an entire industry. In his 1961 story of the Minuteman, Ace in the Hole, journalist and historian Roy Neal described the immense task that lay ahead of the commander of the Western Development Division, Brigadier General Bernard Schriever:

> Tens of thousands of industrial and Air Force managers, engineers, and workers [had] to be trained. New machine tools and test facilities [had to] come into being . . . Literally, he [had to] change the face of America, the make-up of the Armed Forces and the industries that support them.[32]

At the start of the program, virtually no facilities existed that were suitable for the kind of component production and testing required to build and deploy the Minuteman. Furthermore, the political tensions of the Cold War put tremendous stresses on an industry facing almost insurmountable challenges even before it came into existence. The fear of falling behind in the arms race had top military planners struggling to find a way to deliver missiles into the operational inventory as soon as possible. The target date for an operational Minuteman was accelerated from July 1963 to July 1962. The only way this seemingly impossible schedule could be met was to employ the concept of "concurrency," a system of development and production that was introduced, but never fully utilized, in the early planning years of the Atlas and Titan ICBMs. In conventional weapon system development programs, the Air Force would normally build a research airplane, flight test it, then set up the other elements necessary to make it a weapon system. This process usually took at least seven years.[33] The accelerated schedules for the ICBMs

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[30] Schriever interview, 20 June 1973, 6-7.

[31] Jack Raymond, "500 to 5,500-Mile Missile is Approved for Air Force," NYT, 28 February 1958.

[32] Roy Neal, Ace in the Hole, 48.

[33] Ibid, 66.

prohibited this conventional approach. Concurrency was a conceptual system that called for designing production lines, selecting subcontractors, training crews, building bases, and developing ground-support equipment all at the same time.[34] As historian Roy Neal explained:

> By building a higher degree of concurrency into the schedule, by deliberately overlapping development testing, production construction, and site activation to a greater extent, the first operational missiles could be delivered to the Strategic Air Command a full year ahead of the original program scheduled.[35]

The emphasis placed on this development-test concept was unique to the Minuteman ICBM. To build large-scale test and production facilities, and to develop training courses for personnel, all while a weapon system was still in the early stages of invention, was unprecedented. It also came with a price, one which the Air Force decided it was willing to pay. As Schriever warned the Air Force in 1959:

> We have been asked to cut the time by a year and to increase the number of missiles . . . . We may have to compromise some design features. The proposal is conceivable, but the initial product is likely to be degraded. On the early missiles we may have to lose some range or accuracy in the process.[36]

The compromises the Air Force was forced to make in order to meet the accelerated timeline led to the development of another production system feature unique to Minuteman. The Minuteman weapon system was designed from the beginning to accommodate future modifications in all aspects of its technology. The engineers and scientists who created the Minuteman were learning as they built, and before the first version of the missile became operational, they were already finding ways to improve the weapon. One of the first proponents of building this flexibility into the production system was Colonel Otto Glasser, appointed by Schriever to head the Minuteman program in 1958. It was Glasser who suggested, under pressure to deliver the weapon a year early, staggered production lines, set to activate a year apart. Later, if major modifications were required, the second line would take up the slack of retooling time.[37] Eventually, under the

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[34] Ibid, 117.

[35] Ibid, 119.

[36] Ibid.

[37] Ibid, 117.

Kennedy administration, Glasser's idea was made a reality. The ability to make modifications without disrupting production capabilities and later, construction of ground support facilities, was the key to the success and longevity of the Minuteman weapon system.

The Minuteman Program Takes Shape

Finding companies willing and able to accommodate the concurrency concept was not as difficult as the Air Force had first feared. The final plan envisioned one major contract for missile assembly and testing, a second for the guidance system, and a third for the reentry vehicle, which would carry the thermonuclear warhead. The missile's propulsion system, however, was scheduled for three independent contracts, one for each of the three rocket stages. If all went as planned, Minuteman would bring together a team of six "associate prime contractors." On its part, the Air Force intended to serve as overall project manager, relying on Space Technology Laboratories in Los Angeles to assist with systems engineering and technical direction.

By the end of 1958, at least seven of the nation's foremost aircraft manufacturers were competing for the opportunity to build the new missile. Seattle-based Boeing Airplane Company was one of them. Boeing had a long history with the U. S. Air Force, having produced some of their largest strategic bombers, but the company had virtually no direct experience with missiles. Recognizing that it needed to break into this burgeoning field in order to remain competitive, Boeing launched an all-out effort to get the Minuteman assembly and testing contract, assigning 100 people just to put the proposal together. When the contract selection board met to examine the proposals, recalled one top Air Force official, "there was no question . . . that Boeing was the right company for the job."[38] Although Boeing's previous success with the Air Force worked to the company's advantage, there were several more important reasons for its selection. Because most of the required assembly and test facilities did not yet exist, the Air Force was looking for a company with the capacity to fund and build facilities as needed. Boeing had that capacity. Boeing also had the resources to hire as many people as necessary to meet an accelerated schedule. Boeing signed its contract in October 1958. Within two years, its staff on the Minuteman program grew from 100 to over 12,000.

Under its contract, the Boeing Company was responsible for building the airframe of the missile and integrating all equipment furnished by the associate companies into a complete and compatible weapon system.[39] It was also responsible for testing the assembled components and managing

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[38] Ibid, 113.

[39] "Development of Minuteman," Minuteman Service News 1 (Nov.-Dec. 1962): 5.

installation and check-out of the equipment at each launch site. Shortly after Boeing signed its contract, the other members of the Minuteman team were also put into place. The Thiokol Chemical Company of Brigham City, Utah, was responsible for the first-stage motor of the propulsion system; the Aerojet General Corporation of Sacramento, California, was to build the second-stage motor, and the Hercules Powder Company of Magna, Utah, was assigned the third-stage motor. The missile's guidance and control system would be designed by the Autonetics Division of North American Aviation Company in Downey, California; and the Avco Corporation of Boston was hired to develop the reentry vehicle.[40] In addition, the Ralph M. Parsons Company of Los Angeles was selected to design ground support facilities.

Much of the development work for the Minuteman took place in northern Utah. Both Thiokol and Hercules already operated plants in the area, and within a few months, Boeing moved into an enormous new assembly plant occupying 790 acres at Hill Air Force Base near Ogden. By early 1960, Boeing was beginning to put all the pieces together, and Time Magazine reported that the desert north of Salt Lake was "boiling" with activity:

> Strange lights glare in the night, making the mountains shine, and a grumbling roar rolls across the desert. By day enormous clouds of steam-white smoke billow up... and drift over hills and valleys. Monstrous vehicles with curious burdens lumber along the roads. All these strange goings-on mark the development of the Minuteman, the solid-fuel missile that its proponents confidently expect will ultimately replace the liquid-fuel Atlas as the U.S.'s standard ICBM.[41]

By the end of 1960, the first complete Minuteman traveled to Cape Canaveral, Florida, for flight testing. The compact new missile was only six feet in diameter and 53 feet high -- about half the size of a Titan. Its three cylindrical, steel-cased propulsion stages were stacked one atop another, with each stage slightly smaller in diameter than the one beneath it. Each stage contained a rubbery mixture of fuel and oxidizer, molded around a hollow, star-shaped core. The Minuteman's inertial guidance system occupied a small compartment above the third stage. The reentry vehicle at the tip was identical to the nose cone that would eventually contain the missile's thermonuclear warhead.

Following two aborted launch attempts, Minuteman was successfully fired at 11 o-clock in the morning on 1 February 1961. Even the most experienced missile watchers found the event to be

[40] Neal, Ace in the Hole, 113.

[41] "Home of the Minuteman," Time 75 (25 January 1960): 48.

"a dazzling spectacle." The difference was apparent from the very beginning. First there was a loud bang when the Minuteman's first-stage engine ignited. Then the missile rose on a column of flame and smoke. Unlike the Atlas or Titan missiles, which left the ground "like a fat man getting out of an easy chair," the new Minuteman leaped off its launch pad and "shot up like a skyrocket."[42] The missile performed flawlessly once it left the ground. Its three propulsion stages completed their burns precisely on schedule, then detached themselves and plummeted back to earth, while the unarmed warhead hurtled on toward its assigned destination. Twenty-five minutes after liftoff, the nose cone splashed down into the Atlantic Ocean squarely on target -- 4,600 miles from where it had started out. From his office in Washington, Air Force Chief of Staff General Thomas D. White described the launch as "one of the most significant steps this nation has ever taken toward gaining intercontinental missile supremacy." But an engineer who witnessed the event firsthand put it another way: "Brother," he said, "there goes the missile gap."[43]

The Underground Air Force

By the time the flight test took place, plans for deploying the Minutemen were already well under way. According to missile historian Jacob Neufeld, the Air Force had first described its ideas for an ideal ICBM base in March 1955, during the early days of the Atlas program:

> The missile would be sited inside fixed, underground facilities; it was to have a quick launch reaction; it was to be stored in a launching position; the launch site would require minimal support; and the launch units were to be self-supporting for two weeks.[44]

Turning these ideas into reality, however, proved to be an arduous task. The first operational Atlas missiles, hastily activated at the height of the Missile Gap hysteria in 1959, were simply set upright on the launch pads at Vandenberg Air Force Base, California. Later these missiles were stored horizontally in "coffins" -- concrete-walled, aboveground enclosures with open tops. Before the missiles could be fired, they had to be tilted to a vertical position and filled with propellants. The next improvement, in the Atlas "E" series missiles, placed the coffins in earthen berms covered with retractable, reinforced-concrete doors designed to provide a modest measure

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[42] Wesley S. Griswold, "Minuteman, Our Ace in the Hole," Popular Science 179 (July 1961): 62.

[43] "Closing the Gap," Time 77 (10 February 1961): 16. General White is quoted in Neal, Ace in the Hole, 41.

[44] Jacob Neufeld, The Development of Ballistic Missiles in the United States Air Force, 1945-1960 (Washington, D.C.: Office of Air Force History, 1990), 176.

of protection against nuclear blasts. As a further refinement, the Titan I and Atlas "F" series missiles were stored upright in underground, concrete and steel silos capped with massive, double, "clamshell" doors. These installations were designed to withstand blast pressures of 100 pounds per square inch. Concerned that vibration from the rocket engines would shake the missiles to pieces before they left the ground, engineers equipped each silo with an elevator that raised the missile to the surface for firing. Although the missiles were stored with their tanks full of fuel, they still needed to be loaded with volatile liquid oxygen so that the fuel could be ignited. This loading process could only be done after the missiles had been raised to the surface, and it was a slow, delicate operation that increased the weapon's vulnerability and restricted its reaction time.[45]

The Air Force took an important step toward achieving its ideal basing system in 1960, when it began to develop the Titan II -- a second-generation missile that was designed to use completely storable liquid propellants. These missiles could be kept ready with fully loaded propellant tanks and could be quickly fired directly from their hardened underground silos. Nonetheless, the Titan IIs were still highly complex machines that required constant attention from on-site crew members. Consequently, each missile silo was connected to its own adjacent launch control facility.

It was not until the Minuteman missile was added to the American arsenal that the ICBM basing program realized its cherished ideals of protected storage, minimal maintenance, and instantaneous response. Writes Air Force missile historian Ernest Schwiebert:

> With the successful utilization of solid propellants, the Minuteman could hide in its lethal lair like a shotgun shell, ready for instant firing. The operational launcher could be unmanned, underground, and hardened to withstand the surface burst of a nuclear weapon. Each launcher housed a single weapon and the equipment necessary to support and fire it, and required only periodic maintenance. The missiles could be fired . . . at a moment's notice.[46]

Concurrent with the development of the underground silo, engineers were hard at work on a mobile basing system for Minuteman. The idea was to store several missiles in launch-equipped railroad cars that would traverse the country on commercial trackage. The obvious advantage of

[45] Neufeld, Development of Ballistic Missiles, 192.

[46] Ernest G. Schwiebert, A History of the U.S. Air Force Ballistic Missiles (New York: Frederick A. Praeger, 1965), 137.

this system over the stationary silos was the establishment of the missile as a moving target. The mobile Minuteman concept progressed rapidly until President Kennedy opted for an expansion and acceleration of the hardened and dispersed operational program, relegating the railcar-launch system to developmental limbo. In 1961, after a governmental expenditure of $108,000,000, Kennedy killed the program completely.

Deployment and Site Selection

The original Minuteman deployment plan, drafted in 1959, called for the creation of a single, immense "missile farm" equipped with as many as 1,500 missiles. Planners soon determined, however, "that for reasons of economy 150 launchers should be concentrated in a single area, whenever possible, and that no area should contain fewer than 50 missiles."[47] Consequently, the nation's Minuteman force was organized into a series of administrative units called "wings" -- each comprised of either three or four 50-missile "squadrons." Each squadron was further subdivided into five smaller units, called "flights." The command post for each flight consisted of a single, manned, underground launch control center located directly beneath an aboveground launch control support building. By means of both an underground cable and an airwaves communications network, each launch control center oversaw the operation of ten unmanned, underground launch facilities (silos). The silos were dispersed so that an enemy would have to expend at least one nuclear device for each launch facility targeted for destruction. Therefore, silos were scattered sometimes hundreds of miles from support bases. They were also separated from the control center and from each other by a distance of several miles.

The Air Force initially considered deploying the Minuteman as far south as Georgia, Texas, and Oklahoma. But technological compromises required by the speedy delivery of an operational system resulted in deficiencies in range and accuracy in the first version of the missile. These deficiencies dictated the placement of the first Minuteman wings. Planners quickly determined that they could solve the range problem by selecting sites "in the northern part of the United States, relatively close to the Soviet Union."[48]

Next to geographic suitability to ensure target coverage, site geology was the most important determinant in site selection. Surface, soil, bedrock, and hydraulic conditions had to be compatible with Minuteman's construction, maintenance, and launch requirements. Within this limiting framework, the Air Force evaluated areas in terms of military support facilities,

[47] Clyde R. Littlefield, The Site Program - 1961, AFSC Historical Publications Series, 62-24-4, 68. BMO.

[48] Littlefield, The Site Program, 68.

community amenities, transportation infrastructure, and population density -- the last an important consideration for a region that might be subject to nuclear accident or enemy attack. By early 1960, the Air Force had decided to locate the first Minuteman deployment area on the high plains around Great Falls, Montana. This small city offered virtually everything the planners had been looking for. It was the home of Malmstrom Air Force Base, which could provide crucial logistical support for the new installation. The area's low population meant that civilian casualties would be minimized. The region had an established network of improved roads, and there was an abundance of easy-to-acquire public land.[49]

Construction of the Malmstrom complex began in March 1961. The work progressed ahead of schedule, and in the spring of 1962, the Associated Press reported that the Montana silos were being "rushed to completion," and that the first missiles, each loaded with one megaton of death and destruction," would be in place by "late summer."[50] Air Force crews began to lower the weapons into their silos at the end of July, and Malmstrom's first ten-missile flight was hurriedly activated on 27 October 1962, at the height of the Cuban Missile Crisis.

The original 150 weapons at Malmstrom were designated LGM-30A. When deployment began in 1963 at the second Minuteman wing, located at Ellsworth Air Force Base near Rapid City, South Dakota, the missile had already seen a transformation, in the form of a new second-stage motor encased in titanium. Because the titanium unit was lighter than the original steel-encased motor, it allowed for a heavier payload and a greater range. Other changes included modifications to the guidance system, resulting in improved accuracy. Designated LGM-30B, or Minuteman "B," the revamped missile was also installed at Wing III, Minot Air Force Base, North Dakota; Wing IV, Whiteman Air Force Base, Missouri; and Wing V, Warren Air Force Base, Wyoming.

Minuteman Comes to Warren Air Force Base

Atlas site construction had recently ended at Francis E. Warren Air Force Base in Cheyenne, Wyoming, when word came of the decision to make the base home to the fifth Minuteman missile wing of the Strategic Air Command. The announcement came as good news to the community of Cheyenne, which had welcomed the Atlas with open arms in 1958, and intended to do the same with the Minuteman missile.

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[49] Neal, Ace in the Hole, 154-55.

[50] Jack Zygmond, "Montana Minuteman Silos Near Completion," Rapid City Journal, 25 March 1962. Henceforth, citations from this newspaper will be identified with the initials RCDJ.

By the time that announcement was made on 27 March 1962, the people of Cheyenne were accustomed to being "the nation's number one target for enemy missiles."[51] In 1957, the Department of Defense had chosen Warren as the site of the first operational ICBM base in the United States. The attributes that made Warren acceptable for the Atlas missile also attracted Air Force officials looking for a support base and deployment area for the Minuteman. First, Warren provided a 7,520-acre support facility with a well established infrastructure and accessible transportation systems. Second, the area surrounding Cheyenne was a forbidding high plains landscape, containing thousands of miles of sparsely populated grasslands at an elevation of 6,000 feet above sea level. Since lower atmosphere, with its thicker air, drags more strongly on a missile, it is preferable to launch from a high elevation.[52] Finally, southeastern Wyoming -- as well as adjoining northeastern Colorado and southwestern Nebraska -- offered the necessary available real estate the Air Force would need to complete a successful deployment of 200 missiles.

Originally named Fort D. A. Russell, in honor of a Civil War hero, Francis E. Warren Air Force Base came into existence in 1867, in response to the Railroad Act of 1862, which stipulated that a military post be established in Wyoming Territory to protect the Union Pacific railroad builders from unfriendly Indians. In 1930, the post was renamed for the first Wyoming territorial governor and long-time U.S. Senator Francis Emory Warren. During the Second World War, Fort F.E. Warren was an Officer Candidate School for the Quartermaster Corps, and a training center for the Women's Auxiliary Army Corps. German and Italian prisoners of war were confined there until 1945. The fort became an Air Force facility in 1947, when the Army turned it over to the Air Training Command. In 1949, the Air Force redesignated the fort as an Air Force base, keeping the rest of the name intact. The base remained a technical training facility until February 1958, when the Strategic Air Command took it over as the site for its first operational Atlas missile unit, the 389th Strategic Missile Wing.[53]

Building facilities to accommodate 200 Minuteman missiles was a complex cooperative effort of many companies and agencies. Air Force Ballistic Systems Division was responsible for the

[51] Colonel Gerald M. Adams, The Post Near Cheyenne (Boulder, CO: Pruett Publishing Co., 1989), n.p. In 1958, an industrial consultant to the Cheyenne Chamber of Commerce estimated that the Atlas construction program would increase the city's population from 39,000 to 59,000 and pump $100 million into the local economy. Cheyenne's Mayor Worth Story is reported to have greeted the glad news with the statement: "Cheyenne is proud to have the first missile base in the country and proud to be the nation's number one target for enemy missiles."

[52] James H. Winchester, "Missile-Slinging Cheyenne!" New York Mirror Magazine, 29 June 1958, 7.

[53] F. E. Warren AFB, F. E. Warren Air Force Base Directory (Cheyenne: Crazy Horse Publishing Co., 1982).

overall activation of the Minuteman missile sites, a task that extended from site selection through turnover to the Strategic Air Command. Air Force contractors installed and checked out equipment and designed launch facilities, and the Army Corps of Engineers was responsible, through its contractors, for the construction of operational ground facilities.[54]

The Air Force's prime contractor for architecture and engineering was Ralph M. Parsons Company of Los Angeles, the same firm that designed launch facilities for the Titan II missile. Founded in 1944, Parsons began providing services for the military in 1948, designing test facilities for the development of nuclear weapons at Los Alamos, New Mexico. During the 1950s, the company was involved in many advanced aviation projects, including high-energy fuel development programs for the Air Force and Navy, and design work for the Strategic Air Command.[55]

Parsons approached facility design at Warren in the same way it handled the task at other Minuteman deployment areas. Having developed a set of standardized designs for the various site components, the company then adapted the plans to accommodate each new environment. In an ideal time frame, design customarily preceded construction, which preceded equipment installation and check out. However, the Minuteman time frame was anything but ideal. While construction was in progress, Air Force contractors continued to perfect equipment in accordance with the concurrency concept. By it very nature, this process forced the Air Force to adopt changes in the weapon system which set in motion a chain reaction of redesign and construction delays. Parsons often found itself under pressure to rework its drawings even as construction crews toiled and technicians installed equipment.[56]

Construction at the missile sites was coordinated by Morrison-Knudsen Company, an engineering and construction company out of Boise, Idaho. Morrison-Knudsen was well known as one of the major contractors on the Hoover Dam project of the 1930s. The company became entrenched in military contracting during World War II, building airfield facilities and fuel-storage vaults for the Navy in the South Pacific. In the 1960s, Morrison-Knudsen was chosen to build the first silo-based missile installation for the Titan II at Lowry Air Force Base in Colorado.[57]

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[54] Littlefield, The Site Program - 1961, 7.

[55] International Directory of Company Histories, (London: St. James Press, 1988), 11:415.

[56] Littlefield, 71.

[57] International Directory of Company Histories, 1988, 7:355.

Ground was broken for the Minuteman project at Warren Air Force Base in October 1962, starting with Alpha Flight in the 319th Strategic Missile Squadron. Where backhoes and mechanical shovels were utilized to excavate sites at earlier Minuteman wings,[58] construction methods at Warren took advantage of more advanced technologies. Construction crews used a giant rotary auger to drill holes for the 94-foot silos.[59] This method was more efficient than conventional techniques and, coupled with mild autumn weather, propelled the construction program toward the scheduled completion date of spring 1964. However, unusually severe weather in January and June 1963 threatened Morrison-Knudsen's rigid timeline. By August 1963, work was back on track, with open cuts and shaft excavations completed at all sites in Wing V. Silo bases were also complete, and concrete pouring was underway for all 20 launch control center capsules. By November 1963, 90% of the construction work for Wing V was finished.

Morrison-Knudsen completed its work at Warren Air Force Base in June 1964. When the dust had cleared on the whirlwind construction project, the Wing V missile fields contained 200 underground launch facilities (silos), 20 above-ground launch control support buildings, 20 underground launch control centers, and 20 underground equipment buildings. As Morrison-Knudsen completed construction of a flight, the sites were turned over to Boeing, who began installing equipment. Boeing also oversaw final inspection before turning a flight over to Strategic Air Command. On 9 June 1964, with much of Wing V still in various stages of equipment installation, the 319th Squadron's Alpha Flight received the wing's first Minuteman missile from Hill Air Force Base in Utah. By 5 September 1964, all ten missiles in Alpha Flight were on alert. All 200 missiles in Wing V were declared operational on 30 June 1965, 26 days ahead of schedule.

Missile Combat Crews

Wing V was authorized to have a total of 120 missile crews, 30 per squadron, trained to operate the completed Minuteman weapon system. By the end of 1964, the wing had 61 combat-ready crews in place. It took three to four months to train an officer to be part of a two-person missile combat crew.[60] Continuous, multi-phase training characterized the Minuteman training program. Original requirements included the completion of technical courses offered by Air Training Command at Chanute Air Force Base in Illinois followed by "Operational Readiness Training"

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[58] Lauber and Hess, 8.

[59] Headley, Wyoming Tribune-Eagle, 11B.

[60] David Quammen, "The Keys to Kingdom Come," Rolling Stone, 18 January 1987, 61.

at Vandenberg Air Force Base in California. The third phase of training took place at the various missile wings. Officers were paired at the beginning of the local program, continuing their education as formed crews.[61]

At Warren Air Force Base, a missile combat crew consisted of two officers in the grade of captain or lieutenant. From the advent of the Minuteman program until 1988, the combat crews at Warren were all male. Women slowly worked their way into the Minuteman missile program, receiving assignments as cooks and maintenance team members at the launch control support buildings, where latrine and sleeping facilities were modified to accommodate them. In 1986, women began "alert" duty in crews with officers of the same sex at some Minuteman wings, but not Warren. In 1988, Strategic Air Command announced that it would allow women and men to pull alert duty together.[62] In October 1988, Warren welcomed its first woman "missileer," in a gender-integrated crew, who was assigned to the 321st Strategic Missile Squadron.[63]

Alert duty for a missileer in the launch control center lasted 24 hours. Crews were replaced each morning by fresh personnel dispatched from Warren Air Force Base. Missileers pulled an alert duty every three days, averaging between six and ten per month.[64] During an alert, missile combat crew officers spent their time in the capsule performing routine fault monitoring, watching their computer consoles for any sign of trouble at the launch facilities. An electronic monitoring system at the launchers relayed information to the launch control center on the status of the missiles, their support equipment, and the launcher site in general. If the monitoring system indicated a breach in security or an equipment malfunction, the launch control center notified Warren Air Force Base, which sent an appropriate response team to visit the launcher in question.

[61] Starting in 1966, officers trained in Boeing-designed Missile Procedures Trainers at Chanute and Vandenberg Air Force Bases and at Minuteman bases. Missile Procedures Trainers were simulated launch control centers, located on base, which allowed trainees to perform functions and respond to situations as they would in an actual operating launch control center. Continuing advancements in the Minuteman weapon system were reflected in the trainers, which were either replaced or modified to accommodate changes to the actual system. Warren Air Force Base received its first Missile Procedures Trainer in February 1966, with a second trainer arriving in June 1967. Previous to the installation of the on-base Missile Procedures Trainers, crews trained out in the missile fields, in launch control facilities that were temporarily inactivated. "History of 90th Strategic Missile Wing, March 1964," vol. 1. Obtained from the Office of the Wing V Missile Historian, Warren Air Force Base, Cheyenne.

[62] "History of the 90th Strategic Missile Wing, 1 January - 30 June 1988," vol. 1. Obtained from the Office of the Missile Wing Historian, Warren Air Force Base, Cheyenne.

[63] Karina A. Keinanen, "Women Feel Accepted in `Nontraditional' Jobs," Warren Sentinel, 24 March 1989.

[64] Murray Morgan, "The Loneliness of the Missile Attendant," Esquire, July 1964, 50.

During their 24-hour shift, combat crew officers were required to take turns sleeping, and many spent time in the capsule studying. Strategic Air Command initiated an undergraduate college education program in engineering and business for Minuteman crews at Warren in 1965, in an effort to dispel potential morale problems caused by the long hours of confinement.[65] Later, missile crews were able to work toward a masters of science program in business administration. Much of the crew's time was spent performing various drills to keep their responses sharp, including a practice run for launching the missiles. In the event the officers were called to unleash their missiles, they would take their launch keys and preset authenticators out of a locked steel box positioned above their computer consoles. If the orders were determined to be authentic, the officers would insert the codes they received into the enable panel, insert the keys into the switches, and turn them in unison. If the launch command was verified by a second launch control center, a predetermined number of Minuteman missiles would blast out of their silos and streak toward targets halfway around the world.

Minuteman II

Even before Minuteman became operational, the Air Force began to look ahead to a more advanced version of the Minuteman missile. The Air Force's Ballistic Missile Division completed a comprehensive weapon-system study in 1961, and by October 1963, the government issued a requirement for "Minuteman II," with a projected operational date of 1965. The successful flight of the first Minuteman II occurred in September 1964, and as development progressed, funding for the first increment of 200 Minuteman IIs was included in the 1964 national defense budget.

Equipped with a larger second-stage engine, Minuteman II could reach targets 9,000 miles away, compared to the 6,700-mile range of the most updated version of the Minuteman I. Minuteman II was also a more accurate weapon than its predecessor, boasting the first microelectric computer ever to be installed in a missile guidance system. These improvement did away with earlier site deployment and targeting limitations. As one key Defense Department official observed in 1964, "Some targets cannot be assigned to some Minutemen because of their location and because of the range. With Minuteman II, these limitations will become quite unimportant."[66]

In 1963, Secretary of Defense Robert McNamara approved the Minuteman Force Modernization Program. This program called for the replacement of the entire Minuteman I force with

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[65] Michael Binder, "Thirty Minutes to Armageddon," Draft Historic American Engineering Record, WS-133A-M Minuteman II ICBM (Ellsworth Air Force Base, 1993), 57.

[66] "Fixes Planned for Minuteman Deficiencies," Aviation Week and Space Technology 80 (3 February 1964): 26.

Minuteman II ICBMs, and made it necessary to retrofit the original silos, launch control facilities, and ground support equipment at Wings I-V for Minuteman II compatibility. In March 1964, the Air Force began construction of a new missile field, known as Wing VI, for 150 Minuteman IIs at Grand Forks Air Force Base in North Dakota. It also built a smaller Minuteman II installation ("Squadron 20") for Montana's Malmstrom Air Force Base, the home of the first Minuteman installation, Wing I. Otherwise, the deployment of Minuteman II relied on the remodeling of existing launch facilities rather than new construction.[67] Secretary of Defense McNamara set the conversion process in motion in early 1964, when he informed the House Armed Services Committee of his plans to upgrade all of the original Minuteman deployment areas (Wings I-V) by replacing their missiles with the more advanced Minuteman IIs.[68]

The first Minuteman II missile arrived at Grand Forks Air Force Base in August 1965. By that time, the nation's entire Minuteman I force had been declared operational. Modifications to accommodate Minuteman II continued at Wing I (Squadron 20) at Malmstrom Air Force Base, Wing II at Ellsworth Air Force Base, and Wing IV at Whiteman Air Force Base. Wing III at Minot Air Force Base was also slated to received modifications. Wing V at Warren Air Force Base was scheduled to be the last wing modified for Minuteman II.

Operation Looking Glass

One of the upgrades that was initiated during the early days of Minuteman II, was "Operation Looking Glass." Operation Looking Glass referred to airborne launch control centers developed by Boeing for the Strategic Air Command. The flying launch control center operated out of an EC-135 aircraft and had the capability of taking over the duties of a launch control center in the event that it was destroyed. As of 1980, there were 23 aircraft in the airborne launch control center fleet. One aircraft on airborne alert was capable of controlling two Minuteman wings, or about 300 missiles. At least one airborne control center was in the air at all times.[69]

Atlas Deactivated

Events at Warren Air Force Base during the mid-1960s reflected rapidly changing ICBM

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[67] Lauber and Hess, 46.

[68] Hal Taylor, "McNamara Voices Some Optimism Over Nike-X, Tells Minuteman Plans," Missiles and Rockets 14 (3 February 1964): 20.

[69] "Minuteman Update Hinges on Funding," Aviation Week and Space Technology (16 June 1980): 171.

technologies. The Department of Defense made an early decision to retire the Atlas missiles, as the Minuteman could be produced and made operational much more quickly than its liquid-fuel counterparts. When the last of the Atlas missiles at Warren had been deactivated, the 389th Strategic Missile Wing also became extinct. Deactivation of the Titan I was soon to follow.

Force Modification Brings Minuteman III To Warren Air Force Base

The Air Force's Force Modification Program finally reached Warren Air Force Base, but the Minuteman II did not. By the time the Force Modification program began at Warren in 1973, it represented a whole new set of modifications, designed to accommodate the Minuteman III missile, which had been under active development by Boeing since 1965. Construction of Minuteman I facilities at Warren was about halfway completed when military officials first began planning for Minuteman III. In 1963, the Department of Defense initiated an $8 million study and exploratory development program of an advanced ICBM, and by July 1965, the Air Force issued the first Minuteman III research and development contract to the Boeing Company.

The Minuteman III was the first of the three Minuteman versions to reflect its modifications in a substantially different outward appearance. Longer than its two predecessors, the Minuteman III had only one diameter reduction past the first-stage motor, while the earlier missiles had a reduction at each stage.[70] The Minuteman III's technological changes were confined to the third-stage and above. Engineers added a larger third-stage motor to the missile, giving it a longer range and more powerful thrust than the Minuteman II. The most significant difference featured by the Minuteman III was the new Post-Boost Control System that sat atop the third-stage motor. The Post-Boost Control System consisted of two components: the Propulsion System Rocket Engine (PSRE), and an upgraded guidance assembly. The PSRE, manufactured by Bell Aerospace of Buffalo, New York, was an engine that functioned as a fourth-stage bus for the Minuteman's new reentry system by providing added propulsion. It was driven by liquid fuel, the only such rocket engine in the solid-fueled Minuteman program.[71] The guidance assembly was similar to that on the Minuteman II but had an increased power supply and more computer memory for better accuracy in positioning the reentry vehicle. Surmounting the Post-Boost Control System was the new reentry system, the Post-Boost Vehicle, enclosed in the bullet-shaped tip of the missile. The Post-Boost Vehicle contained what the New York Times called the missile's "most telling advantage," the "revolutionary" Mark 12 Multiple Independently Targeted

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[70] "Minuteman III is Coming!," Minuteman Service News 38 (May-June 1968): 3.

[71] Michael L. Yaffee, "USAF Reconfigures Minuteman ICBMs," Aviation Week and Space Technology 99 (5 November 1973): 54.

Reentry Vehicle (MIRV). The MIRV could deliver three 200-kiloton warheads that were independently positioned to hit three separate targets, a capability that would "render current and contemplated antimissile defense systems largely inadequate," and would thus "thrust the world into a new era of weapons for mass destruction."[72]

Test flights of the Minuteman III began in August 1968, with a successful launch from Cape Kennedy, Florida. As testing continued, objections to the Minuteman III mounted in Congress. In early 1970, in response to the profound implications of the missile's MIRV component, Senator Edward W. Brooks spearheaded an effort to persuade President Richard Nixon to postpone the deployment of the multi-warhead missile. Arms control talks between the Soviets and the United States were scheduled for April in Vienna, and Brooks called for a delay until arms control negotiators could discuss the subject. In defense of an on-schedule deployment for the Minuteman III, Air Force secretary Robert C. Seamans, Jr. told the Senate Armed Services Committee that, in the event of a Soviet attack, "Minuteman III improvements will insure that our surviving missiles could penetrate the Soviet anti-ballistic missile system."[73] In supporting testimony, Air Force Chief of Staff General John D. Ryan agreed that the Minuteman III was necessary because the Soviet operational ICBM force already outnumbered that of the United States, and that by mid-1971 it would "probably exceed ours by several hundred launchers."[74] Pentagon officials also cited Soviet developments as a key reason for the new missile, maintaining that the Soviets were believed to be deploying a 50-megaton, multiple warhead on the SS-9, their most powerful ICBM. These arguments, and the fact that the Minuteman III program was well underway by the time the opposition gained momentum, left proponents of the new weapon confident that the President would move the deployment ahead as scheduled. By March 1970, despite the protestations of a substantial Congressional faction, it became clear that the Minuteman III program would continue without delay.[75]

Minot Air Force Base received the first 150 Minuteman III missiles in 1970, and the new weapons were fully operational by 1971. Grand Forks Air Force Base became operational in 1973 with 150 Minuteman III missiles, and Warren Air Force Base achieved operational status with Minuteman III in 1975, with 200 missiles. In addition, Squadron 20 at Malmstrom Air Force

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[72] "Two Missiles to Get Test Today," NYT, 16 August 1968.

[73] "Minuteman 3 Deployment Slated," Aviation Week and Space Technology 92 (16 March 1970): 23.

[74] Ibid.

[75] "Minuteman III's Spring Planting," Business Week, 28 March 1970, 130.

Base received 50 Minuteman IIIs, bringing the total count to 550 missiles. The new system was designed to operate from existing Minuteman I and Minuteman II launchers, with relatively little alteration of the ground facilities.[76] The launch facilities saw the most change, as the Minuteman III was longer than the first two Minuteman missiles for which facilities were originally designed. Each launch tube was equipped with a new suspension system, designed to hold the missile absolutely motionless during the aftershocks from a nuclear attack. The Minuteman III brought little change to the physical appearance of the launch control facilities. However, important modifications were made to the computer programming inside the launch control centers. The Air Force began installing an innovative retargeting system called Command Data Buffer (CDB) at Warren in 1973. The CDB facilitated rapid, remote retargeting of the missiles in the event target priorities were reshuffled.[77] In the past, these operations were done manually by maintenance crews who brought new tapes to the silos to reset the missile guidance computer. Retargeting with Command Data Buffer meant that a missile combat crew member could transmit new target constants to individual missiles within their flights from the launch control center. This innovation added an operational command and control flexibility that previously was unavailable to Strategic Air Command.[78] By January 1975, facilities at Wing V at Warren were fully converted from Minuteman I to Minuteman III. The Boeing Company completed the conversion ahead of schedule, at a cost of $109 million.

Rivet Save

In 1977, Strategic Air Command initiated the "Rivet Save" program. The impetus behind Rivet Save was a need to cut back on military spending to accommodate defense budget reductions. Missile crew positions were targeted for elimination as part of these reductions. The original missile system had smaller manning requirements than the Minuteman II and III. The Minuteman I crew force worked on a 24-hour alert schedule, which was efficient because crews arrived from base for their alert shift, then immediately returned to base after the shift. Replacement crews also came directly from base, so there was no need for crews to wait for their next alert in the aboveground support building. Crew members got the rest they needed inside the capsule, taking turns sleeping so the consoles were continuously monitored. But each modification to the weapon system placed new demands on the missile crews. Under such conditions, the National Security Agency (NSA) felt crew members could no longer be permitted to sleep on their alert shift.

[76] "Minuteman III Work Begins," Minuteman Service News 48 (January - February, 1970): 3.

[77] Barry Miller, "ICBMs Get Major Modification," Aviation Week and Space Technology 104 (10 May 1976): 68.

[78] Ibid.

Consequently, the Minuteman II and III force switched to a 36-hour alert system, whereby each crew would pull a 12-hour alert, rest aboveground for 12 hours, then pull another 12-hour alert. As one crew rested, another crew would man the launch control center. The system kept a second crew idle in the launch control support building for up to twelve hours at a time. Under Rivet Save, the NSA agreed to allow a return to the more efficient 24-hour alert schedule, if measures were taken to increase the security of the missile system against unauthorized launch. These changes had no impact on the appearance of the launch control support building or the launch control center. Rather, they involved computer reprogramming coupled with modifications to the coding process and to the enable panel in the launch control centers.[79]

Peacekeeper

Once Minuteman III deployment was underway, Strategic Air Command planners began their search for a third generation ICBM that could more effectively utilize multiple independently targeted reentry vehicle technology. In April 1972, the Air Force assigned the designation "Missile-X" (M-X) to the advanced ICBM and made the Space and Missile Systems Organization responsible for developing it.[80] Later called Peacekeeper, the missile was a four-stage ICBM capable of carrying up to ten independently targetable reentry vehicles. The development of the Peacekeeper had a direct impact on the Minuteman III force at Warren. Because of ongoing concern about the vulnerability of silo-based missile systems, Congress would approve funding for only 50 Peacekeepers until an alternative basing system was devised. Because of time constraints in testing and developing alternative basing systems, the first 50 Peacekeepers were designed to launch from existing Minuteman silos. In 1986, the Strategic Air Command began deploying 50 Peacekeeper missiles in modified Minuteman III silos assigned to the 400th Strategic Missile Squadron at Warren Air Force Base. The 50 Minuteman III missiles removed from the silos were transported to Hill Air Force Base in Utah. Full operational capability occurred at Warren in December 1988, when the 90th Strategic Missile Wing accepted the fiftieth Peacekeeper missile.[81]

[79] "History of the 90th Strategic Missile Wing, April - June, 1977." Obtained from the Office of the Wing V Missile Historian, Warren Air Force Base, Cheyenne.

[80] From Snark to Peacekeeper, 43

[81] Ibid, 47.

Rivet MILE

At the same time the Peacekeeper was being deployed at Warren Air Force Base, the Air Force initiated a major Minuteman upgrade and modification program. Rivet MILE (Minuteman Integrated Life Extension Program) began in April 1985. This joint Strategic Air Command and Air Force Logistics Command effort was the largest single missile logistics program ever undertaken within the ICBM program.[82] Unlike earlier modification programs, Rivet MILE was not an upgrade of the weapon system, but of the facilities that supported the weapon system. This $493 million program focused on the reconditioning, repair, and maintenance of launch facilities and launch control facilities.[83] It was phased in three-year increments, with cycles running from 1985-1988, 1988-1991, and 1991-1994.

The Rivet MILE upgrade program began at Wing V in 1988. The launch control support buildings received the most visible modifications, including new steel siding, new windows, and interior remodeling to accommodate newly installed female crew members.[84]

The End of the Cold War

During the late 1980s, the world saw unmistakable signs that the lengthy Cold War period was over. By the end of the decade, the Berlin wall had been dismantled, Germany had been reunified, and a number of former Eastern Bloc nations had replaced their Communist regimes with democratically elected governments. As the new decade began, the Soviet Union disintegrated rapidly as its constituent republics declared their independence one by one. When the Warsaw Pact was dissolved in March 1991, the enemy that President Ronald Reagan had once called "the evil empire" essentially ceased to exist.[85] Four months later, on 31 July 1991, President George Bush and Russian leader Mikhail Gorbachev signed the Strategic Arms Reduction Treaty (START), which placed a limit on the number of ICBMs and prescribed a process for the destruction of their launch facilities.

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[82]Ibid, 39.

[83] Eugene Kozicharow, "Six-Year Program Will Modify Minuteman Launch, Control Facilities," Aviation Week and Space Technology 112 (4 February 1985): 93.

[84] Jack B. Knudson, Wyoming, to Karen Hardy-Hunt, Colorado, 18 April 1994, State Historic Preservation Office, File #O294TPT016, Cheyenne, Wyoming.

[85]"End of the Cold War," The CQ Researcher 2 (21 August 1992): 721.

The START agreement coincided with growing Air Force disenchantment with escalating costs associated with repairing and maintaining the older Minuteman II system. Rather than upgrade Minuteman II facilities with Minuteman III, the Pentagon decided to deactivate the entire Minuteman II force to help comply with provisions of the arms-reduction treaty. On 27 September 1991, Bush appeared on national television to announce a dramatic "plan for peace," designed to reduce the tensions of the nuclear age. As one component of his plan, he called for "the withdrawal from alert, within 72 hours, of all 450 Minuteman II intercontinental ballistic missiles." Bush's announcement did not immediately affect Warren Air Force Base, with its contingent of Minuteman III and Peacekeeper missiles. These weapons were to remain on alert.

The Air Force saw the end of the Cold War as a time of transition. In June 1992, after 34 years of controlling U.S. land-based ICBMs, Strategic Air Command was inactivated. At the same time, several new commands were established, including Air Combat Command, which took over daily management of the ICBM force, and Strategic Command, a unified administration of the Navy and Air Force, which became responsible for planning and target selection for all strategic weapons. The following year, in July 1993, Air Force Space Command assumed daily management duties for the ICBM force from Air Combat Command.[86]

During these administrative changes, the Air Force continued to invest in the Minuteman III weapon system. In 1989, a $669 million program called Rapid Execution and Combat Targeting Program (REACT) was initiated to replace the original outdated computer systems that the missile combat crews were using to monitor and control launch facilities, retarget the weapon system, and process incoming messages.[87] Deployment of the REACT consoles began in 1995.[88]

Conclusion

Between Warren, Grand Forks, Malmstrom and Minot air force bases, 500 Minuteman III missiles currently stand alert. These missiles are scheduled to remain operational until at least the year 2020.[89] During the 1990s, the capability to deploy a single reentry vehicle was added to the

[86] Michael Binder, "Thirty Minutes to Armageddon," 83.

[87] "Description of Proposed Action and Alternatives for Launch Control Center Modifications REACT Program," 10 September 1991, State Historic Preservation Office, File #O193TPT005, Cheyenne, Wyoming.

[88] The base museum at Warren displays one of the original consoles that was replaced during the REACT modification program. The console at the museum came from a training module at Vandenberg Air Force Base instead of a Wing V launch control center; however, it is identical to the ones used at Warren from 1964 to 1995.

[89] Binder, 83.

Minuteman III's MIRV system to allow strategic planners greater flexibility in meeting warhead reductions mandated by arms limitation treaties.[90] Because START called for the elimination of multiple-warhead land-based ICBMs, the ten-warhead Peacekeeper will be retired. As a future modification, either one or two of the Peacekeeper's Mk 21 reentry vehicles may be deployed on the Minuteman III when the Peacekeeper system is deactivated.[91]

Land-based ICBMs still play a vital role in American defense strategy as part of the "Triad," the three major American weapon systems standing guard for the United States in the name of strategic deterrence. The other two components of the Triad are the Navy's sea-based ballistic missile fleet and the Air Force's Bomber fleet. Each system has its unique advantages: the land-based missiles are dispersed and hardened; the sea-based missiles are constantly moving; and the bombers have tactical warning and quick reaction capabilities. Their features are complimentary, each member of the Triad providing a function the other cannot.[92]

The dispersed and hardened basing system of the Minuteman missile is the component which gave credence to the concept of "massive retaliation," as an effective deterrent to a Soviet first strike. Throughout the history of the Minuteman weapon program, pressure has been building to explore alternative basing methods. It is unknown at this time what the long-term plans are for the current system. As evidenced by the rapid and concurrent way in which the Minuteman missile was developed, military systems are uniquely adaptable to the latest technologies, but their life spans are vulnerable to changing political forces.

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[90] ICBM System Program Office, The Minuteman Weapon System History and Description, (Utah: Hill AFB, 1996).

[91] Binder, 83.

[92] Ibid, 11.

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